(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 344 839 A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 89201319.4

(51) Int. Cl.4: H05B 6/64

(22) Date of filing: 22.05.89

(30) Priority: 01.06.88 NL 8801407

(43) Date of publication of application: 06.12.89 Bulletin 89/49

(84) Designated Contracting States: BE DE FR GB NL

(71) Applicant: KONINKLIJKE EMBALLAGE INDUSTRIE VAN LEER B.V.
Amsterdamseweg 206
NL-1182 HL Amstelveen(NL)

(72) Inventor: Turner, Peter Gatenby
Conincksmeer 14
NL-3645 WG Vinkeveen(NL)

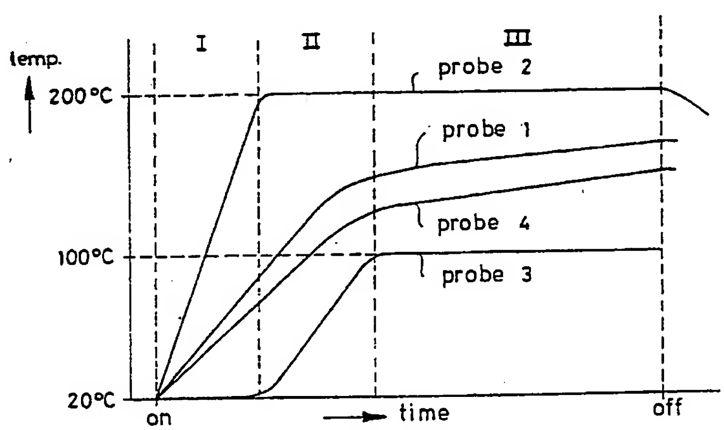
(74) Representative: de Bruijn, Leendert C. et al
Nederlandsch Octrooibureau
Scheveningseweg 82 P.O. Box 29720
NL-2502 LS 's-Gravenhage(NL)

(54) A bi-functionally active packaging material for microwave food products.

(57) A bi-functional laminate which in a microwave oven converts irreversibly, after a time and at a temperature controlled by the components of the laminate, from a microwave screen with absorbing properties to a microwave transparent material with much weaker absorbing properties. The said laminate is constructed from

- a plastic film selected for its compatibility for food contact and for its softening temperature which determines the changeover conversion temperature;
- a metal layer vacuum deposited on the plastic layer, the metal being deposited to just sufficient thickness to provide a complete screen to microwave transmission at room temperature (transmission less than 1%);
- an adhesive and
- a paper or paper-board supporting material of a weight selected to give the required heat-up time to the changeover conversion temperature, said supporting material being adhered to said metal layer.

fig-10



A bi-functionally active packaging material for microwave food products.

This invention relates to a new class of microwave active materials, which can be used in suitable configurations to improve the cooking of many foods in microwave ovens by generating crisping and browning conditions on the surface.

The way in which electromagnetic waves, which include microwaves, interact with metal surfaces is well understood and is described by Maxwell's laws. The reflectivity of metal surfaces to light and microwaves is attributed to the high electrical conductivity of the surface. When the metal is present in the form of a very thin film, the surface layer which interacts with the electromagnetic wave shows significant electrical resistance and reflection is reduced and absorption becomes significant, the absorption resulting in a temperature rise. At even lower thickness the resistivity of the surface (conventionally expressed as ohms per square) further increases to the point where reflection is very small, absorption is significant, and some radiation can transmit through the metal. At even lower thicknesses, the metallic resistance becomes so high that there is no electrical interaction with electromagnetic waves and microwaves or light can transmit through.

Use has been made of the ability of thin metallic layers to absorp electromagnetic waves in susceptor materials which are used in the microwave heating of food products to create a hot surface to induce surface browning and crisping of pastry products or to provide a hot plate to supplement microwave heating for the popping of pop-corn. Such materials and packages have been described by Brastad, Seiferth, Turpin et al.

In these prior art and current practice applications, a laminate is made from a lightly metallised heat resistant plastic film bonded to a supporting structural layer of paper or paperboard. The metallisation thickness, usually expressed as optical density (OD) or sheet resistance (ohms per square) is controlled to such a level as to maximise microwave absorption to provide rapid heating of the resultant laminate in a microwave oven. Because of this very rapidly heating laminate surface the outside of the food product will be heated rapidly. On the other hand materials with good absorbing properties will transfer a part of the microwaves so that simultaneously also the inside of the food product is heated by the microwaves. This heating of the inner food product will cause migration of fluids to the outside of the food product, which prevents the desired forming of a brown grispy crust at the outside of the food product.

By contrast, the material of this invention, offers a major advance over existing susceptor materials which are used in the microwave food industry by operating in a dual or bi-functional mode. The material of this invention is metallised to a greater thickness so that the layer is totally opaque to microwave radiation (although not necessarily totally opaque to the much shorter wavelength visible electromagnetic radiation), yet not so thick that it loses all absorption properties.

More specifically the invention provides a bi-functional laminate which in a microwave oven converts irreversibly, after a time and at a temperature controlled by the components of the laminate, from a microwave screen with absorbing properties to a microwave transparent material with much weaker absorbing properties; said laminate being constructed from

- a plastic film selected for its compatibility for food contact and for its softening temperature which determines the changeover conversion temperature;
- a metal layer vacuum deposited on the plastic layer, the metal being deposited to just sufficient thickness to provide a complete screen to microwave transmission at room temperature (transmission less than 1%);
- an adhesive and
- a paper or paper-board supporting material of a weight selected to give the required heat-up time to the changeover conversion temperature, said supporting material being adhered to said metal layer.

When such a material is used in a box configuration, the preferred embodiment of this invention, it provides initially a total screening of the food contents from microwave radiation.

During this period it heats up, but less rapidly than prior art material because of its lower absorption properties, to final temperatures of 200 - 250 °C. (which can be selected by the method of manufacture of this invention as will be explained hereinafter).

During this first warm-up stage, the food product is heated only on its outer surface by contact with or thermal radiation from the heating box. The crisping action on the surface of the food starts without microwave heating of the inside of the food product.

Surprisingly, when the material of the box construction reaches the aforesaid elevated temperate, it spontaneously converts to a material having quite different interactive properties with microwaves. Instead of acting as a screen for microwaves, it acts as a transparent window to microwaves yet retains just sufficient absorbing power to maintain its elevated temperature. During this second phase, the hot surface

of the material continues to heat the surface of the food product maintaining the conditions necessary to promote browning and crisping, and simultaneously the microwaves can penetrate into and will be absorbed by the food product to rapidly warm or cook the whole food product.

What is believed to occur is that the heat generated by microwave absorption in the metal creates thermally induced stresses in the laminate structure due to high thermal gradients and differences in thermal expansion of metal, plastic substrate, and adhesive layers. Below the transition temperature, the solid nature of the component contain these stresses. But at a characteristic temperature determined by the materials of construction, the material softens and can no longer withstand the thermal stresses.

Thermal distortion occurs on a micro-scale which causes the very thin and mechanically weak metal layer to break. This breaks the electrical continuity on the scale significant to microwave wavelengths and destroys the reflective properties.

In this state, the metal layer is irreversibly converted to a microwave transparant layer retaining weak absorption properties. This function contrasts with that described by Brastad in US patent 4,267,420, in which the heating effect arises from current flowing between high resistance micro-cracks which are formed in the metal layer.

The invention will be explained in more detail with reference to the attached drawings.

Figure 1 illustrates a cross-section through a metallized plastic film used for carrying out different measurements.

Figure 2 illustrates the transmission, absorption and reflection of aluminium coatings on a plastic film as function of the optical density.

Figure 3 illustrates in another way the transmission, relfection and absorption of aluminium coatings on a plastic film as function of the optical density.

Figure 4 illustrates the same values as Figure 3 now, however, as function of the sheet conductivity.

Figure 5 illustrates the transmitted, reflected and absorbed microwave power, expressed as percentage of the inciding microwave power on a stainless steel layer as function of the optical density of the stainless steel layer.

Figure 6 illustrates in another way the transmission, reflection and absorption for a stainless steel layer as function of the optical density.

Figure 7 illustrates a cross-section through a laminate according to the invention.

Figure 8 shows various boxes made from the laminate according to the invention.

Figure 9 illustrates the circumstances during practical measurements.

Figure 10 illustrates the results of the measurements.

To establish the right metal coatings for the bi-functional effect according to the invention, the transmission, reflection (and by calculation the absorption) properties of thin metal coatings were measured by passing microwaves through a film sample mounted in a wave-guide and, using a network analyser, observing the forward and reflected powers on the two sides of the material. The film samples were embodied as schematically illustrated in Figure 1 and consisted of a layer 1 representing a plastic film selected for compatibility with food stuffs and a layer 2 representing the metal film layer. Using a range of metallised films of different thickness, the relationships shown in the graphs in Figures 2 to 6 were found. The figures 2, 3 and 4 are more specifically related to aluminium coatings. The measurements, graphically illustrated in Figures 2 and 3, show that for aluminium with an optical density of less than 0.1, which corresponds to a sheet resistance greater than 1000 Ω/■, the materials are totally transparent to microwaves at the frequency used in microwave ovens (2.45 GHz).

At an optical density of about 0.2, corresponding to a sheet resistance of aground 100 Ω/■, the absorption shows a maximum of about 50% of the incident radiation with transmission and reflection more or less equally sharing the remaining 50%. This is the material preferred by those skilled in the art for generating a hot-plate surface for crisping an browning products for microwave cooking. At an optical density of 0.6, the transmission of the microwaves has fallen to zero, and the material is predominantly a reflector of microwaves, yet still absorbs between 10 and 20 percent of incident microwave radiation. At greater thicknesses the reflection increases to approach 100% with a consequent reduction in microwave absorption and microwave heating.

Figure 4 illustrates the transmission (T), absorption (A) and reflection (R) of microwave energy for vacuum deposited aluminium coatings as function of the sheet conductivity. The conductivity is for the purpose of the description defined as:

conductivity = 100/sheet resistence (Ω/■).

The conductivity is along the horizontal axes expressed on a logarithmic scale. Unfortunately the data for conductivity values lower than about -0,5 were not available at the time of writing this description, however,

it appears clearly that the transmission, reflection and absorption curves shows a similar behaviour as illustrated in Figure 2.

In Figure 5 the transmission (T), absorption (A) and reflection (R) of microwave energy is illustrated for stainless steel coatings as function of the optical density of the stainless steel coating.

In Figure 6 the same values for stainless steel coating films are illustrated as function of the sheet conductivity (taking into account the above mentioned definition).

It appears from Figures 5 and 6 that also stainless steel coatings show similar behaviour of the transmission, absorption and reflection of microwave energy. Unfortunately also in Figures 5 and 6 no values for lower sheet conductivities were available at the time of writing this description. There is, however, no doubt that the various curves will show a great similarity with the curves for the aluminium coatings in Figures 2 and 4.

The metallised coating required for this invention is that showing the properties of the 0.6 OD aluminium metallized films, or the 0,4 OD stainless steel metallized films, i.e. films with a microwave transmission at 2.45 GHZ of less than 1% and a microwave absorption between 10 and 20%. The coatings optimally have a sheet of resistance of 10 - 20 Ω/■, whether aluminium or some alternative metal or alloy.

The material of the invention, which is used in a preferred closed or open-ended box configuration, comprises a laminate of metallised plastic film adhesive bonded to a paper or paper-board. Such a laminate is illustrated in Figure 7.

Referring to Figure 7, layer 3 represents a plastic film selected for compatibility for contact with food stuffs and for its softening point. Table 1 lists plastics commonly used in food packaging and their softening temperatures.

Table 1

Temperature transition of different plastic film materials.

Plastic	Softening Point	(type*)
Cellulose based films	under 100°C	(1)
Polyvinyl chloride (PVC)	80°C	(2)
Polyethylenes	108 - 132°C	(3)
Polycarbonate	150°C	(2)
Oriented polypropylene	170°C	(2)
Polyvinylidene dichloride (PVDC)	205°C	(3)
Nylon 6	215°C	(3)
Polyester imide	215°C	(2)
Polybutylene terephthalate (PBT)	224°C	(3)
"TPX"	245°C	(3)
Nylon 6-6	255°C	(3)
Polyethylene terephthalate (PET)	260°C	(3)
Polyimide	310°C	(2)

* Softening points listed are literature values of
1) heat distortion temperatures
2) glass transition temperature
3) crystalline melt temperature

The thickness may be any thickness compatible with its use, typically in the range 5 to 100 microns.

A preferred material is biaxially oriented polyester film 12 of microns thick.

Layer 4 in figure 7 represents the metal layer applied by vacuum deposition techniques - evaporation or sputtering - to the plastic film 3 to a controlled thickness to give the required microwave screening properties. Different metals require different thicknesses due to their differing electrical properties. The metal can be any corrosion resistant metal or alloy compatible with use in food packaging, e.g. aluminium, stainless, steel or titanium. The thickness required for aluminium would have a sheet resistance of about 15 Ω/■,i.e. signifcantly higher than the coatings described by Seiferth (0.4 - 8 Ω/■).

The optical density of such an aluminium coating is around 0.6 which is signficantly higher than the 0.2 to 0.3 used in the simpler hot-place type of mono-functional materials representing the known art.

Layer 5 represents the adhesive which is selected for its compatibility for food packaging application. This layer 5 provides the bond to layer 6, a paper or paper-board which serves both to provide structural stiffness to the laminate and final configuration, and to moderate in a controlling manner the heat-up rate of the laminate when exposed to microwave radiation. Where the laminate is not in direct thermal contact with the food-stuff in use, then the heat-up rate is controlled primarily in inverse proportion to the thermal mass of the supporting paper-board.

Figure 8 illustrates several possible configurations of the shaped material, an essentially closed structure being necessary to achieve effective initial screening of the product.

a) Represents an open-ended four-sided box suitable for square or rectangular food products with a pastry crust such as pies.

b) Represents a closed six-sided box with optional ventilation holes suitable for fish fingers, chips or rectangular pies.

c) Represents a hexagonal (or tubular) sleeve suitable for sausage rolls for example.

d) Represents a polygonal shallow box suitable for pizzas or round pastries and pies.

e) In contrast with the other illustrated embodiments which are formed from a flat laminate in this embodiment the metallized plastic layer structure is attached to a preshaped package made of paper or cardboard, which package in this example is embodied as a shallow box with an approximately similarly shaped cover.

Example

A laminate was made by adhesively bonding a 12 µm polyester film, metallised with an aluminium coating to an optical density of 0.6 and showing zero microwave transmission, to a 240 gram per square meter paper-board.

A rectangle of this laminate was folded into a 4-sided open- ended sleeve (similar to Figure 8 (a)) which allowed an easy fit for a sausage roll. Four microwave insensitive temperature sensing probes were attached to the sleeve and product. Probe 1 was positioned beneath the sausage roll attached to the inward-facing plastic film surface of the open box. Probe 2 was attached to the upper inner surface of the box. Probe 3 was inserted into the sausage meat filling. Probe 4 was inserted just below the skin of the outer crust of the sausage roll. The positions of the four probes are schematically illustrated in Figure 9. In this Figure the enclosure, formed of the laminate according to the invention is referred by number 10, the food product is indicated by 11 and comprises a crust 11a and a filling 11b. Furthermore the four probes are indicated as such.

The sausage roll with its bi-functional surrounding pack, complete with positioned temperature sensing probes, was placed in a domestic microwave oven. The temperature rise of the four sensors was continuously monitored during the heat-up period. After 90 seconds cooking the sausage roll was removed. Both the filling and the pastry were hot (as also indicated by the probes) and the pastry was crisp and flaky.

A similar sausage roll heated in the microwave oven without the bi-functional pack remained cool on the surface and the pastry was damper and limper than before warming.

The temperature changes are shown in schematically Figure 10. The two different functions carried out by the laminate according to the invention are clearly seen from these curves. In figure 10 three different stages are distinguished, indicated by I, II and III. During stage I, the product is screened from microwaves and no heating of the filling occurs. Probe 3 does not measure any temperature increase. The surface of the laminate (probe 2) heats up relatively rapidly to a high temperature which with the used laminate was in excess of 200 °C. Because the surface of the laminate forms a relatively large heat sink, the surface of the laminate which is in contact with the food product was heated up, however, significantly less rapid than

those parts of the surface which were not in contact with the food product. This is indicated by the temperature increase measured by probe 1. Furthermore probe 4 indicated that also the free parts of the crust surface will start warming up.

When the material of the pack reaches its ultimate temperature (in this example ± 200 °C), it converts to a microwave transparent material which simultaneously has weak absorbing properties. Therefore the temperature of the laminate will not rise further, but will be stabilized at the obtained value. The reaching of the maximum temperature marks furthermore the beginning of the second stage, indicated by II. During this stage II the sausage meat filling starts to rise in temperature as appears from the values supplied by probe 3, whereas also the temperature of the crust (measurement values supplied by said probes 1 and 4) continues to rise. Because at every moment the crust is hotter than the filling the crust will show a tendency to lose water so that the crust will become crispy and flake.

If the measurement would be repeated without the enclosure according to the invention than the filling of the sausage roll would heat up faster than the crust so that the crust would show a tendency to lose water into the crust resulting into a damp and weak crust, which certainly does not have the desired crispness.

At the moment the filling of the sausage roll reaches a temperature of about 100 °C the temperature will stabilize as result of the relatively large water content within the filling. From that moment on in fact the last stage begins, which stage is indicated by III in figure 10. At any suitable moment in time the cooking process can be ended within this stage, preferably at a time selected by the user at which time the crust has obtained its desired appearence, in other words when the outer crust has obtained its desired crispness and browning. At that moment the microwave oven is switched off and the cooked food stuff can be taken out of the oven.

Claims

1. A bi-functional laminate which in a microwave oven converts irreversibly, after a time and at a temperature controlled by the components of the laminate, from a microwave screen with absorbing properties to a microwave transparent material with much weaker absorbing properties; said laminate being constructed from

- a plastic film selected for its compatibility for food contact and for its softening temperature which determines the changeover conversion temperature;
- a metal layer vacuum deposited on the plastic layer, the metal being deposited to just sufficient thickness to provide a complete screen to microwave transmission at room temperature (transmission less than 1%);
- an adhesive and
- a paper or paper-board supporting material of a weight selected to give the required heat-up time to the changeover conversion temperature, said supporting material being adhered to said metal layer.

2. A laminate according to claim 1 where the metal layer has a sheet resistance of 8 to 25 ohms per square.

3. A laminate according to claim 1 or 2, where the plastic film is polyethylene terephthalate.

4. A laminate according to one of the preceding claims where the metal layer is aluminium of optical density 0.5 to 0.7.

5. A laminate according to one of the preceding claims where the metal layer is deposited on the plastic film by vacuum evaporation or sputtering.

6. A laminate according tto claim 1 where the metal layer is stainless steel or titanium.

7. A laminate according to claim 1, characterized in that that supporting layer of paper or cardboard is preshaped into an enclosure.

8. Enclosure from a laminate according to one of the preceding claims, which enclosure is open ended or completely closed, and is destined to enclose a food product during the cooking of said food product in a microwave oven, which enclosure provides initially for screening of the food product in a large extend in relation to the microwaves.

fig-1

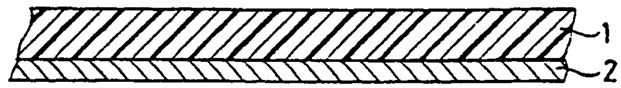


fig-10

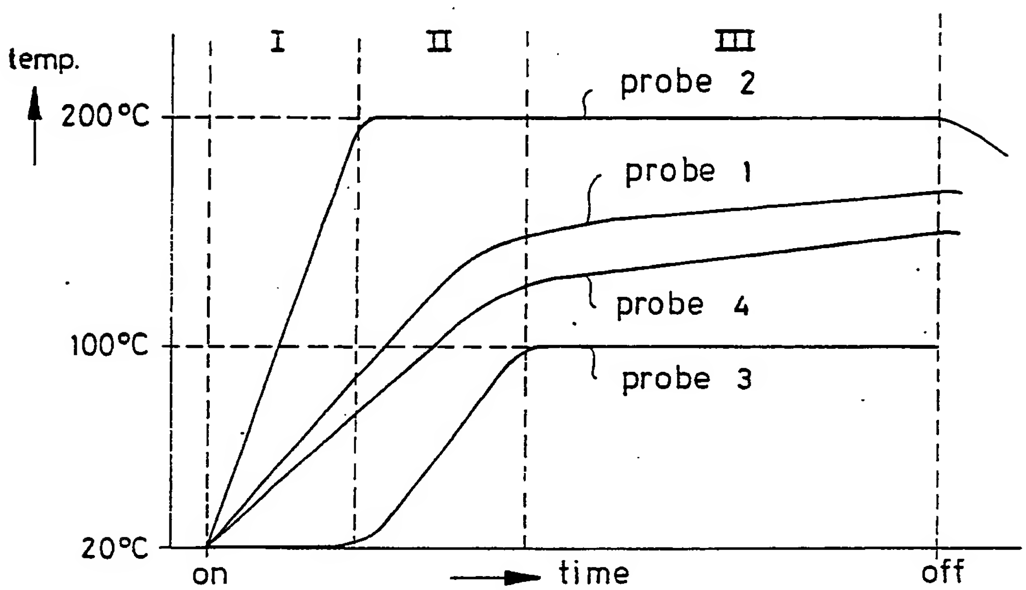
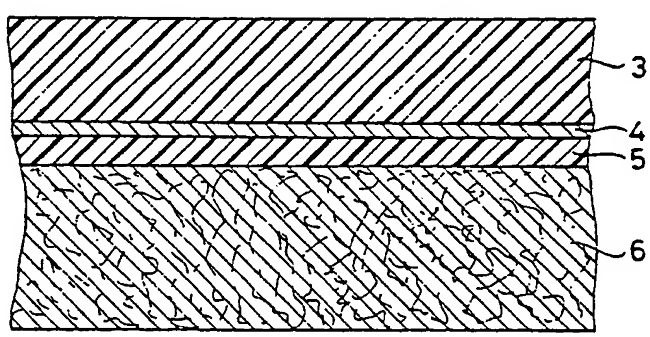


fig-7



BEST AVAILABLE COPY

fig-2

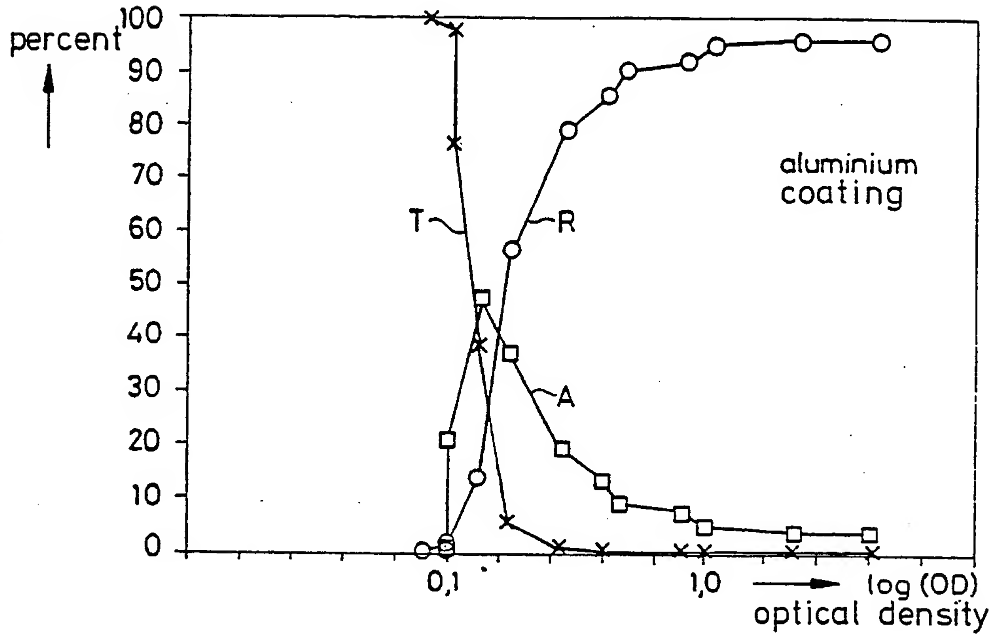

percent
100
90
80
70
60
50
40
30
20
10
0
T
R
A
aluminium
coating
0,1
1,0
log (OD)
optical density

fig-3

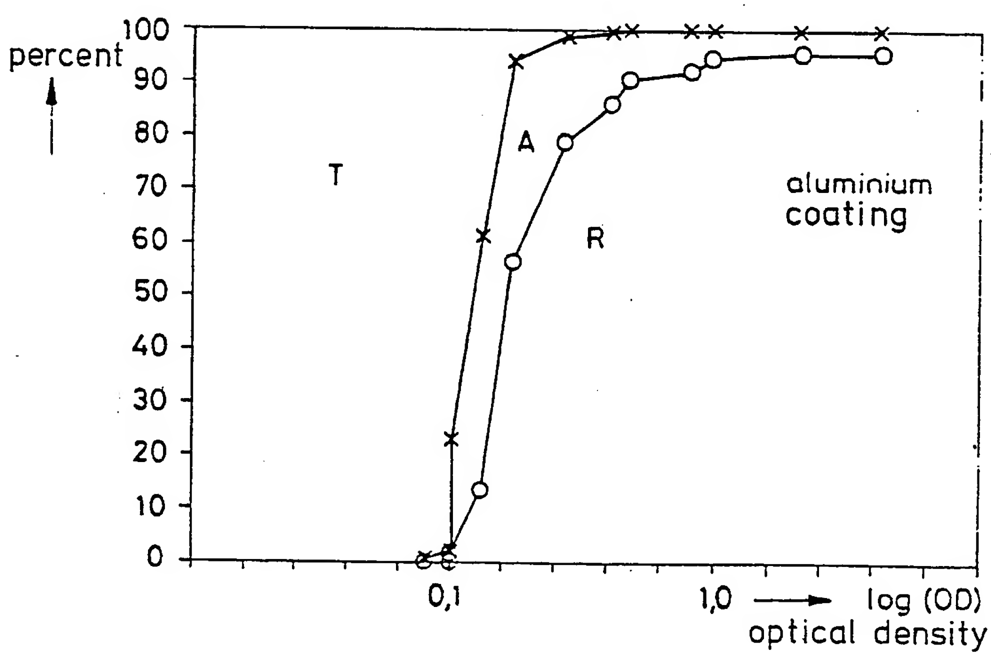

percent
100
90
80
70
60
50
40
30
20
10
0
T
A
R
aluminium
coating
0,1
1,0
log (OD)
optical density

Fig-4

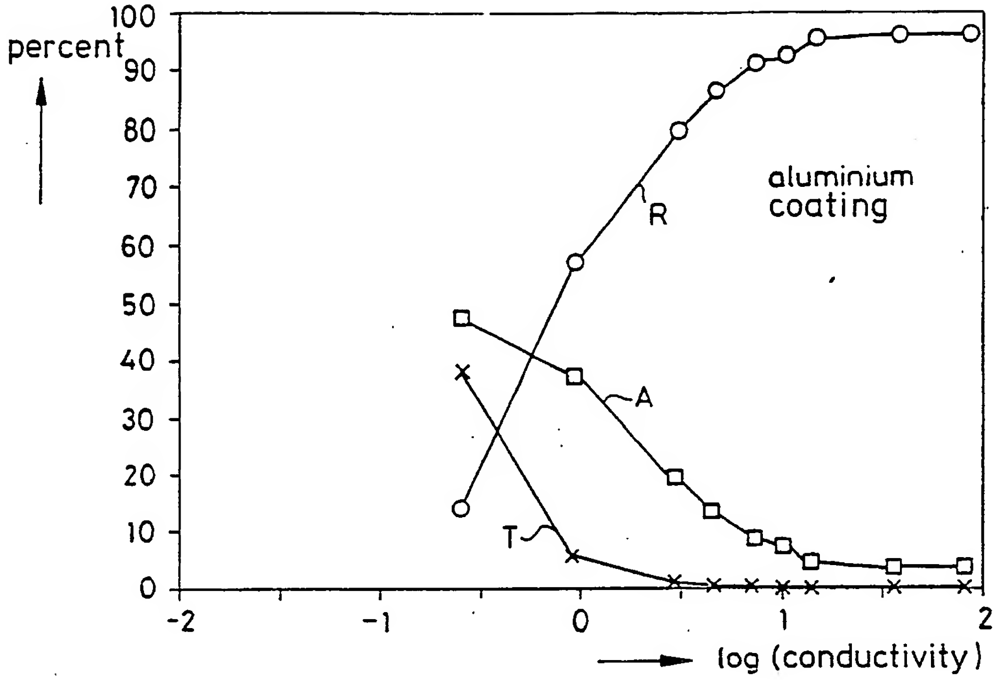
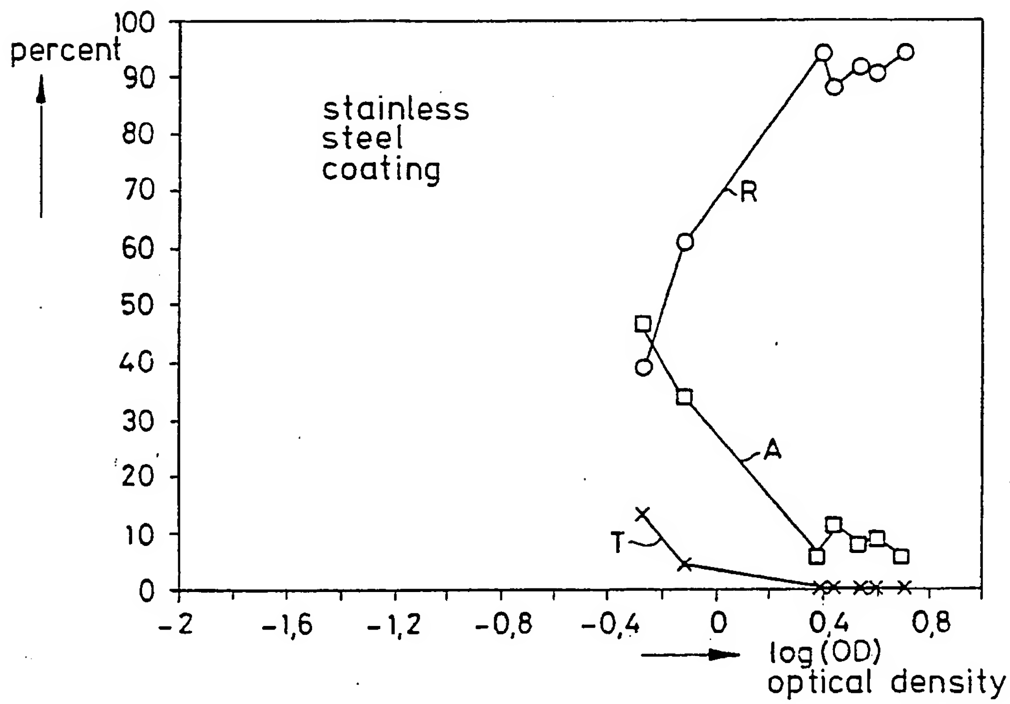


Fig-5



BEST AVAILABLE COPY

Fig-6

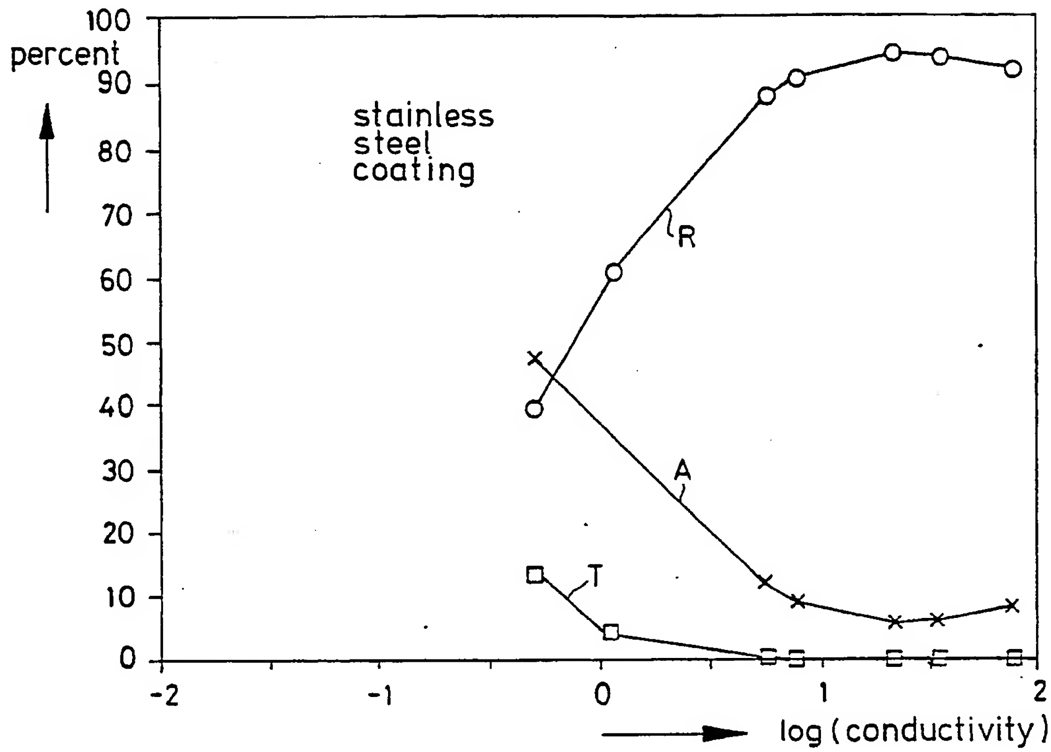
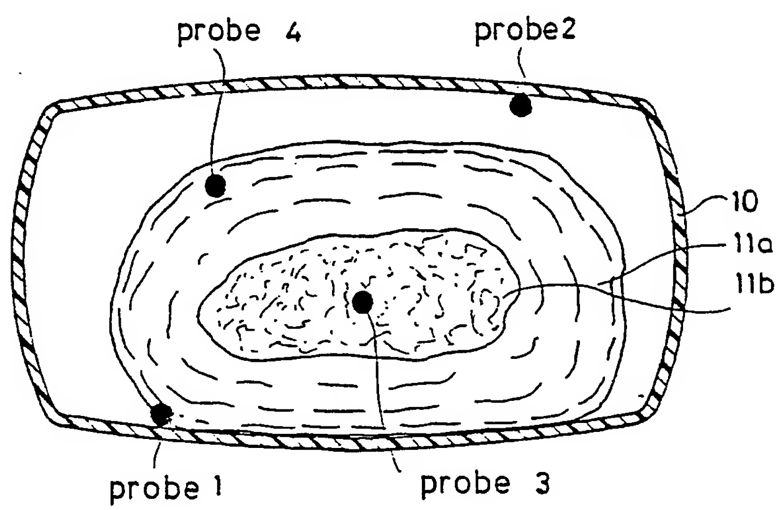


Fig-9



BEST AVAILABLE COPY

fig-8a

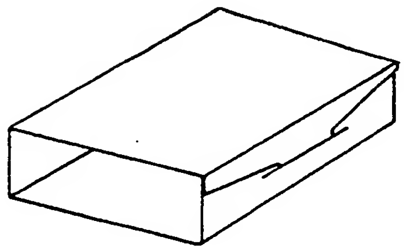


fig-8b

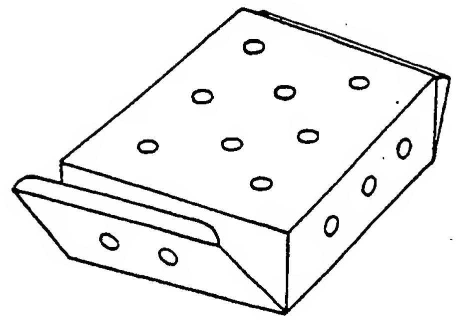


fig-8c

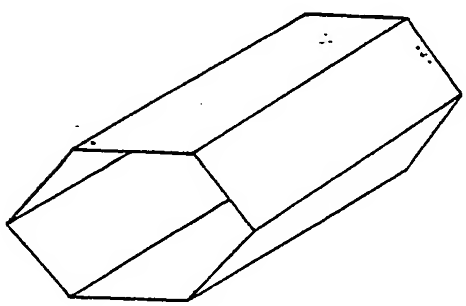


fig-8d

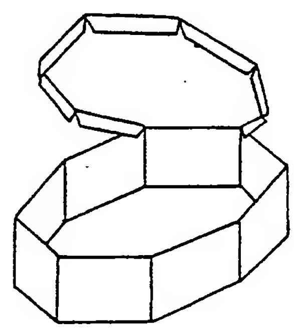
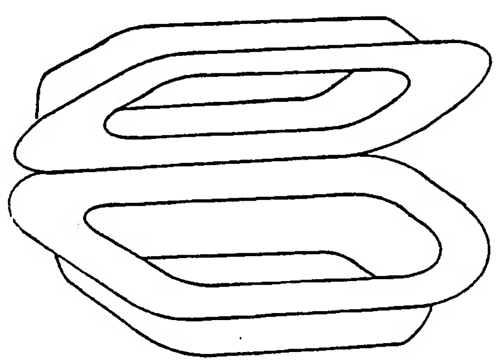


fig-8e



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 20 1319

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	FR-A-2451182 (SEIFERTH) * page 3, line 20 - page 4, line 30; figure 2 *	1, 3-5, 7, 8	H05B6/64
A	EP-A-000797 (THE PROCTER & GAMBLE CO.) * page 12, line 17 - page 13, line 14 * * page 21, lines 1 - 17; figures 2-5 *	1, 3, 4, 8	
A	EP-A-242952 (E.I. DU PONT DE NEMOURS AND COMPANY) * page 3, lines 30 - 40 * * page 3, lines 48 - 53 * * page 4, lines 15 - 21 *	1, 3-8	
A	EP-A-245005 (INTERNATIONAL PAPER COMPANY)		
A	US-A-4230924 (BRASTAD ET AL.)		
A	US-A-4713510 (QUICK ET AL.)		
A	EP-A-251445 (INTERNATIONAL PAPER COMPANY)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 AUGUST 1989	RAUSCH R.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)